27. Notes on the Anatomy of *Cacopus systoma*, an Indian Toad of the Family Engystomatidæ. By D. W. Devanesen, M.A.*

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(Text-figures 1–19.)

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1. *Introduction.*

Cacopus systoma is an Indian toad of the narrow-mouthed, edentulous and fossorial type belonging to the family Engystomatidæ, well-known for their habit of feeding upon ants and termites. Among the chief characters which distinguish the genus are the following: the palate has two dermal transverse folds more or less denticulated, one behind the vomers and the other in front of the œsophagus; there are no pre-coracoids; the sternum is a large cartilaginous plate; and the transverse processes of the sacral vertebra are rather strongly dilated.

The following notes were compiled in India during what was intended to be a comprehensive study of the morphology of *Cacopus systoma*. Comparisons with the anatomy of certain other toads of the same family and comments thereon have been made wherever suitable.

This work was done in the Zoological Laboratory of the Madras Christian College, Madras. Grateful acknowledgment is hereby made for suggestions and advice to Prof. W. Rae Sheriffs of the college mentioned, and to Dr. J. R. Henderson, F.L.S., formerly Superintendent of the Government Museum, Madras. To Prof. MacBride's encouragement the communication of this paper is due; for this and for reading the manuscript, I thank him.

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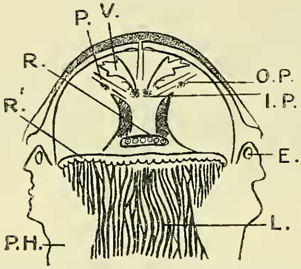
* Communicated by Prof. E. W. MacBride, D.Sc., LL.D., F.R.S., F.Z.S.

2. *The Viscera.*

The second dermal ridge on the palate of this toad is a conspicuous structure stretching across from one eustachian opening to the other, its edge being thrown into well-marked denticulations. On laying open the pharynx*, one finds immediately behind this ridge and in close contact with it and occupying more or less the same level, a differentiated area of about 80 sq. mm. (text-fig. 1). Transverse sections through the same revealed the fact that it consisted of closely-set, parallel, and longitudinal reduplications of the mucous membrane of the pharynx, each fold containing an extension of the basement membrane (text-fig. 2). A fold is on an average 1 mm. in height; the highest folds are found in the middle, and from this place the height of the folds on the sides gradually decreases. These folds show a faint tendency to anastomose, and their free edges hanging down into the cavity of the pharynx, in the fresh condition, appear swollen. This specialised area of the pharynx may, in my opinion, be given the status of an organ for two reasons: first, it is compact, having a certain definite outline, and it is restricted to a definite place, namely immediately behind the second dermal ridge; secondly, as the free end of the tongue lies, when in a state of rest, underneath this area, and since the presence of the intermaxillary glands is doubtful in this toad, the structure in question is probably a substitute for these glands, possessing a similar function; the cells of the mucous membrane in these folds are comparatively large and sacciform, which facts are perhaps suggestive of their glandular nature.

Text-figure 1.



"The Pharyngeal Organ of *Cacopus systoma*" exposed; the lower jaw and the floor of the mouth have been cut away. L., lamellæ arranged lengthwise; R., the first, short, R.', the second, long, denticulated ridge; E., eustachian opening; V., vomer; I.P., inner dark papilla on the toothless hind end of a vomer (V.); O.P., an outer one on the vestigial palatine (P.); P.H., pharynx cut open and deflected.

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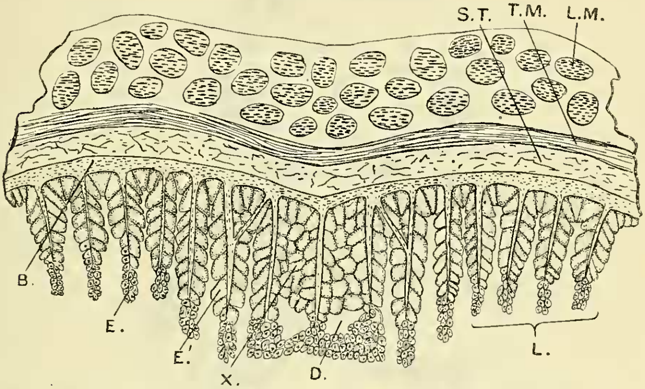
* That part of the alimentary canal between the second dermal ridge and the stomach, I propose to call "the pharynx," as it is much wider than it should be for an œsophagus which is probably unrepresented in this toad. The cavity enclosed between this ridge and the jaws may be termed "the oral cavity."

I therefore propose to call this the "pharyngeal organ" of *Cacopus systoma*. It will be interesting to know if this structure is present in the other members of the family Engystomatidæ.

On the outer surface of the pharynx, from each of the two points roughly corresponding to the two ends of the second dermal ridge, is given off a slip of tissue which is attached to the free end of that arm of the pterygoid meeting the cranium. This arrangement is presumably for the purpose of holding up the pharyngeal wall which, in this region, is particularly heavy with the dermal ridges and the "pharyngeal organ" described.

The longitudinal folds of the mucous membrane of the stomach appear to be more numerous than in *Rana*, and in the convex region thereof they show a tendency to anastomose. The liver consists of but two lobes. Among the numerous specimens I examined, I found eight—six females and two males—suffering from stone in the bladder. The proximal part of each oviduct where it opens into the cloaca becomes enormously dilated into a sac, which may be distinguished as a uterus. In this bag probably the eggs are stored before they are finally passed out. It consists of a thick-walled, less capacious anterior portion and a membranous spacious posterior part. The internal lining of the former is thrown into numerous, densely-packed, villi-like processes, visible to the naked eye. The two bags or uteri are, along their inner sides, intimately connected by tissue; I do not think that there is an actual fusion between their walls. The kidney possesses a simple lobe towards the hind inner end.

Text-figure 2.

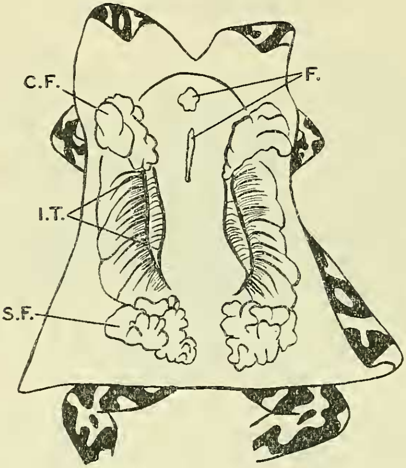


A transverse section through the middle region of "the pharyngeal organ." L.M., outer lengthwise muscles of the pharynx; T.M., inner trausverse ones of the same; S.T., sub-connective tissue; B., basement membrane; L., lamellæ; E., ordinary stratified epithelial cells; E.', the same epithelial cells enlarged and forming a sac; X., cell-mass resulting from the fusion of two adjacent lamellæ; D., an incipient duct.

3. *The Sub-cutaneous and other Fat-bodies**.

The occurrence of sub-dermal fat is by no means peculiar to this toad; several species among the Anura are known to possess it, though its function in most of them still remains to be elucidated (Boulenger, C. L., **3**). Accumulations of the fat in question are found in *C. systoma* chiefly in two situations: (1) in the neck-region above and below, in connection with the lymphatic maxillary septum; this lobular mass of fat may be termed "the cervical fat-body (text-figs. 3 and 13); and (2) in the inguinal region on the dorsal surface in relation with the lymphatic inguinal septum, which is very high and falls into folds; in the same region, but to a less extent, fat is developed in connection with the iliac sac and the posterior lymph-heart; this extensive area of fat, in its totality, may be called "the supra-inguinal fat-body" (text-fig. 3). Besides these two conspicuous sub-dermal fat-bodies, one occasionally finds scanty deposits of the same substance under the skin in the parietal and occipital regions, in a small median area dorsally behind the head and on the under side of each arm near the brachial vein. I assume that these, too, are developed in relation to the lymphatic system.

Text-figure 3.



The skin on the back cut open and the sub-cutaneous fat-bodies exposed in a male C.F., cervical fat-body; S.F., supra-inguinal fat-body; F, fatty deposits on the head and neck; I.I., conspicuous *inscriptiones tendinæ* of the *obliquus* muscles, seen only among males.

One also finds in this toad certain internal deposits of fat which presumably are sub-peritoneal fat. These are found in relation to the blood-vascular system and the vertebral column. The auricles and the *truncus arteriosus* are thickly covered with fat, and the ventro-auricular groove is filled with the same; this cardiac fat, it should be observed, is found on the inner layer of the pericardium. Small quantities of fat occur also on the walls of the *inferior vena cava*, where it opens into the *sinus venosus*. In close proximity to the vertebral column is situated a longitudinal patch of fat on both sides extending from the fourth vertebra to the ninth, and a small median deposit where the cranium articulates with the atlas.

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* Young specimens show neither an adequate development of these fat-bodies nor are they present in all the places mentioned.

Among the other Indian frogs I examined, sub-dermal as well as sub-peritoneal fat in relation with the blood-vascular system was found in *Rana hexadactyla*, the analogous form in India to *Rana esculenta*, and in *Rana breviceps*, a burrowing species. Nevertheless, in these instances, while fat under the skin is confined to the neck-region, even that does not occur so regularly. The same fat in the inguinal region has been noticed by other observers in several species of *Bufo* (3), *Xenopus lævis*, and notably in *Hemisus guttatum*, an American Engystomatid (1); in the first-mentioned toad, however, it is ventrally situated, while in the last one there is a complicated development of the same in connection with the iliac sac which does not obtain in *C. systoma*.

As this Indian toad has a remarkable habit of burrowing underground when the dry-season commenced and of passing into a torpid state, it struck me that these fat-bodies might have a nutritive value to the animal during that æstivating period. Therefore, in July and August, 1911 and 1912, I obtained by special efforts a considerable number and examined them. It was found that both the sub-dermal and sub-peritoneal fat-bodies had undergone, in accordance with my expectations, a great reduction in size and a change in colour from yellow to dull white, as compared with specimens examined during the wet-season.

From the above considerations one may draw the following conclusions:—Fat occurs normally in several places in the body of *C. systoma*, both internally and under the skin. While the pre-renal fat-bodies may be looked upon as feeders to the gonads during the breeding season, the other fat-bodies in this toad may be regarded as assisting in the general nutrition of the body during æstivation. It is noteworthy that in *Bufo*, *Hemisus*, and this toad the sub-dermal fat is developed in connection with the lymphatic system.

4. *Discussion on "the stout shape"* of* C. systoma.

A remarkable feature of the two toads of this genus is, as several observers have noted, the rotund shape of the body. This has been, till now, accounted for in various ways. Thus, Günther (6) observed regarding *C. globulosus* that it was due to a certain fluid contained in the abdominal cavity and the extraordinary development of the ovaries in the female. But Pearson (7) remarks as follows:—"Günther states that this distension is caused by a fluid contained in the abdominal cavity. A brief examination shows that this is not thecase, and that the fluid-containing cavity is none other than the sub-cutaneous lymph-sinuses which are greatly enlarged in this form. The dorsal sinus is especially spacious, and has a height of 15 mm. from floor to roof. (The length of the frog from mouth to vent is 75 mm.)

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* *Vide* figure in Boulenger, G. A. (2), p. 496.

"In Günther's account he speaks of the distension of a female specimen being due to the growth of the ovaries, and his description suggests that the ovaries grow into the large cavity on the back. This is not possible, as the sub-cutaneous lymph-sinuses are separate from the cœlom. There is only one other species in this genus, namely *Cacopus systoma*, which differs but slightly from *C. globulosus*, and which resembles it in the robust appearance due to the enlargement of the sub-cutaneous lymph-sinuses. This interesting character is not given in the diagnosis of the genus either by Günther or Boulenger."

Thurston (8), with reference to the same species, says:—"On laying open the visceral cavity, the globular shape was found to be due to an enormous distension of the œsophagus and stomach, the latter occupying nearly the whole of the abdominal cavity, and the remaining viscera &c. being compressed and lying posteriorly. There was no distension of the intestinal tract. The distension of the œsophagus and stomach was found on section to be caused by the presence in their cavities of a mass of winged white ants (termites) which when dried weighed 326 grains."

The descriptions of Günther are based on slender evidence, namely the examination of two specimens in spirit. So far as I was able to observe in several fresh specimens of *C. systoma*, I did not find an excessive quantity of the peritoneal fluid beyond what should generally be expected in the abdominal cavity. The supposition that the development of the ovaries is a source of the stoutness may at once be dismissed, as it can apply only to females, and again in them it is seasonal as in all batrachians. So also Thurston's hypothesis, as food cannot be regarded as a permanent cause.

I find that the stout shape of the body in this toad cannot be accounted for by any one character, but by a combination of features as the following:—The viscera as a whole exhibit a great development which is disproportionate to the small dimensions of the abdominal cavity. They therefore press against the sides of the abdomen and bring about a characteristic rotundity of the same. A feature which has not been noted as regards this toad is the inclusion of the proximal portion of the thigh into the trunk. The skin of the thigh is drawn along with that of the body, and consequently the contour of the latter begins posteriorly about the middle of the thighs*. This, I should think, improves upon the effect produced by the viscera. The enlarged lymph-sinuses, with the lymph and fat-bodies contained therein, enhance the stout shape.

The purpose of the enlarged lymph-spaces of the two toads of this genus is perhaps to be sought in their fossorial habits. The liberally secreted lymph may serve to protect the internal organs from injuries incidental to animals with such habits. The muscles of the abdomen in *C. systoma*, chiefly the *rectus abdominis*, form a weak protection, as they are stretched to their utmost capacity by the pressure of the enormously-developed viscera. The presence of a fluid between the latter and the skin must, under such circumstances, serve to diminish the chances of injury from outside. This supposition is strengthened by the fact that larger quantities of lymph were found in specimens obtained during the dry weather than in those examined during the wet-season.

5. *The Axial Skeleton.*

An examination of the bones of the head revealed certain facts which, in my opinion, account for the narrow mouth of this toad in particular, and probably also for that of several other members of the same family in general. While the contour of the mouth which corresponds to the distal circumference of the skull, is a parabola in *Rana*, the same has been in this animal reduced to a mere arc. Assuming that the skull-morphology in *Rana* is primitive, one can trace the narrow mouth in question to a generally vestigial condition of most of the bones of the suspensorium. Thus the squamosal has lost the anterior arm or the zygomatic process, what remains probably corresponding to the middle † and posterior arms of the same in *Rana* (text-fig. 4 A). The palatine, for another instance, is so inconspicuous, being about 3 mm. long, that it can only be found in skulls very carefully prepared. The remaining bones of the suspensorium also exhibit in a greater or a lesser degree the same degenerate state; the cumulative effect of this, in all probability, was the forward displacement of the articular head for the lower jaw. For, a line drawn along the suture between the nasals and the fronto-parietals cuts the orbital fossæ at about the middle and passes through the heads in question (text-fig. 4 C), whereas in *Rana* the same line lies far in front of the last (text-fig. 4 D). This shifting of the articular heads necessitated by the vestigial condition of the bones of the jaws has probably led to a diminution in the contour of the mouth.

The cranium as a whole is remarkable for its shortness and

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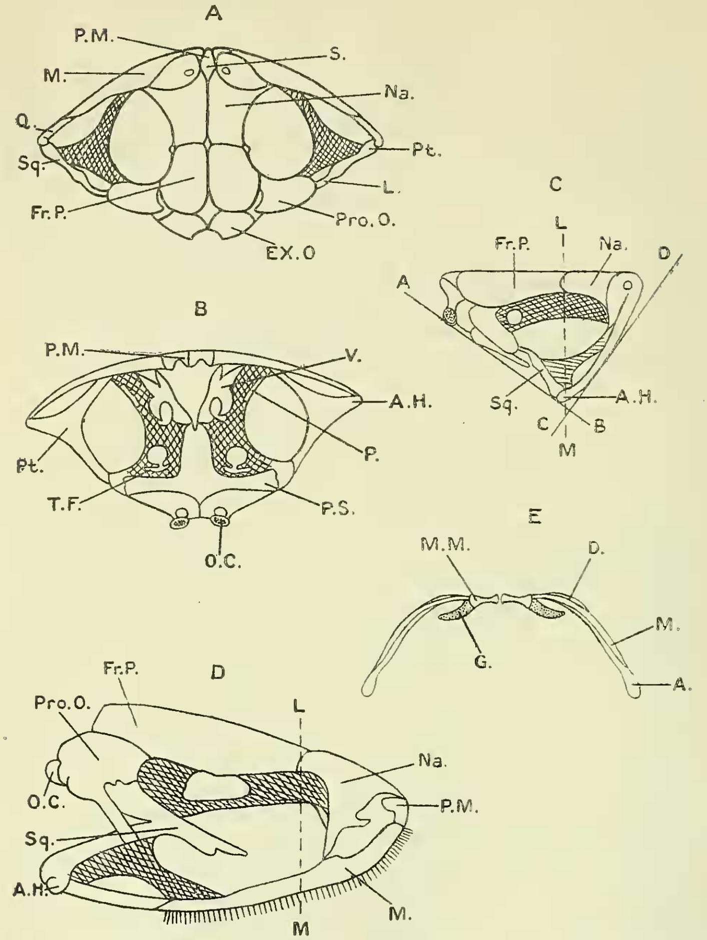
* This character is greatly exaggerated in *C. globulosus*, judging by the specimen in the Government Museum, Madras. Beddard (**1**) has recorded a similar condition, still more pronounced in *Breviceps verrucosus*, an Ethiopian Engystomatid.

† The presence of this middle arm is also doubtful, as the attachment with the pro-otic is by means of a ligament which may, however, be taken to represent this arm.

Text-figure 4 (A, B, C, D, and E).



A. A dorsal view of the skull of *Cacopus systoma.* The vestigial condition of the squamosal (Sq.) is remarkable. L., ligament connecting the latter with the pro-otic. For other letters consult the key-list of abbreviations.

B. A ventral view of the same. P., vestigial palatine; T.F., trigeminal slit. For other letters consult the previous text-fig. (**A**) and the key-list of abbreviations.

C. A lateral view of the same. L–M., a straight line drawn along the suture between the nasals and the fronto-parietals of the cranium. A–B, the plane in which the proximal circumference of the skull lies. C–D, the plane in which the distal one of the same lies. A.H., articular knob for the lower jaw; Fr.P., fronto-parietals; Na., nasals.

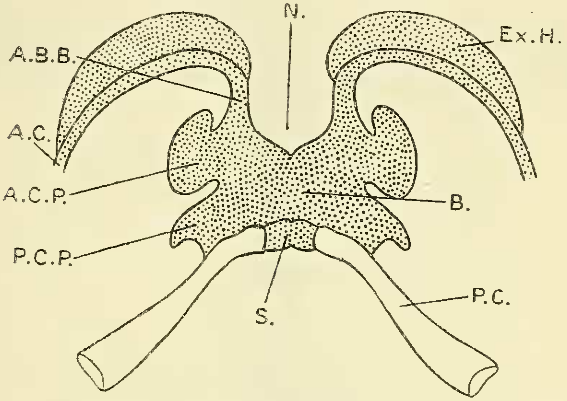
D. A lateral view of the skull of *Rana hexadactyla.* A brief comparison of the *Cacopus* skull with this will reveal the differences mentioned in the text. L.M., the same vertical line mentioned in the previous text-fig. (**C**). For other letters consult key-list.

E. Lower jaw of *Cacopus systoma*, as seen from below. A., angulosplenial; M., Meckel's cartilage; D., dentary; M.M., mentomeckelian; C., cartilaginous portion of the latter.

relatively greater width, this being mainly due to the sphenethmoid, which is extremely short, and it does not exhibit the prismatic shape usually seen in that of *Rana*. Each mentomeckelian of the lower jaw carries at its posterior end a cartilaginous triangular piece which stretches behind and is free from the other component parts of the same jaw. These two pieces are useful in so far as they provide partial attachments to the *sub-mentalis* muscle below and the *genioglossus* above (text-fig. 4 E).

The semilunar piece of cartilage in connection with the anterior cornua of the hyoid bone in *Hemisus*, described and identified as "the extrahyal" by Beddard (1, p. 909), appears to be represented also in this toad (text-fig. 5, Ex.H). A closer approximation and fusion of the two extrahyals would complete the notch into a foramen corresponding to that of *Hemisus*.

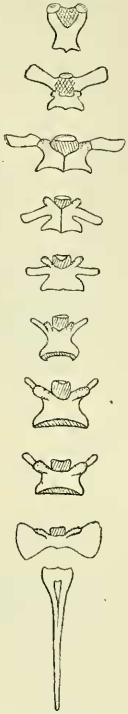
Text-figure 5.



The hyoid skeleton of *Cacopus systoma* viewed from below. Ex.H., "extra-hyal' A.C., anterior cornu; P.C., posterior cornu; B., basihyal or the hyoid plate; A.C.P., anterior cartilaginous process of the basihyal; P.C.P., posterior one of the same; A.B.B., anterior body-process of the basihyal or the proximal part of an anterior cornu; N., notch between the latter; S., thick cartilaginous part between the proximal ends of the two posterior cornua, probably belonging to the latter.

In the vertebral column of this toad one finds also a few interesting features. The transverse processes are comparatively short, taking the size of the centra and the neural arches into consideration; those of the third vertebra are the longest; next in order follow the ninth, fourth, second, eighth, seventh, sixth, and the fifth; the last three may be subequal. The spinous processes may be said to be absent in the first, sixth, seventh, eighth, and the ninth vertebra, while in the rest it is probably represented by a faint median ridge. The thick transverse processes of the second, third, and the fourth vertebra, the thin and slender ones of the fifth, sixth, seventh, and the eighth vertebra (those of the last three being directed conspicuously forward), the much dilated one of the sacrum, and the crestless urostyle combine to give a characteristic appearance to the vertebral column of this toad (text-fig. 6). It may be mentioned that the sacral diapophyses are remarkable for their uncommonly well-developed epiphysial cartilage at their free edges.

Text-figure 6.



A dorsal view of the bones of the vertebral column of *Cacopus systoma*.

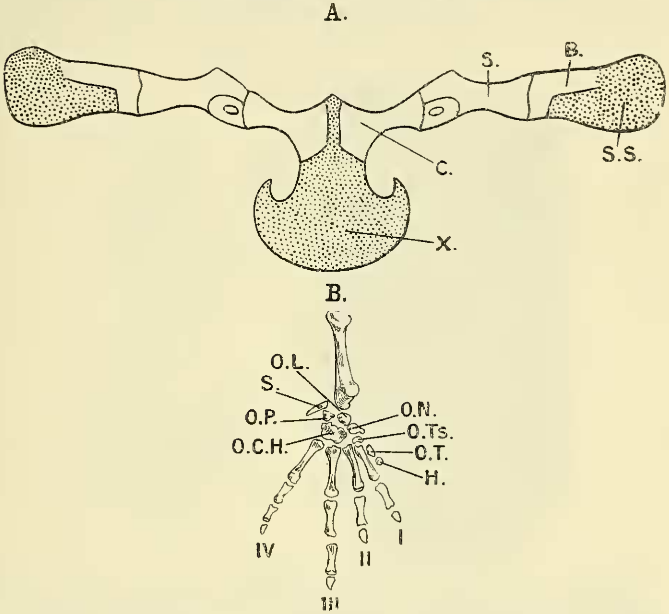
I noticed an interesting abnormality in one specimen, namely the occurrence of two sacral vertebræ, the posterior one being fused with the urostyle. This condition is found normally to exist in *Pelobates*, *Pipa*, and *Hymenochirus* (**5**, p. 22).

6. *The Appendicular Skeleton.*

In the pectoral girdle the absence of the precoracoid probably necessitated the disappearance of the omosternum and the episternum. In the place of the sternum proper and the xiphisternum, one finds a broad, flat plate of cartilage generally calcified in the centre. This plate gives attachment to four different muscles, viz., the *obliquus-internus*, the inner portion of the *sternohyoideus*, "*sternocornuoideus*," and the "*abdominis-sternalis*," the last three to be described later in the section on muscles. This probably accounts for the unusually large size of this xiphisternal plate (text-fig. 7 **A**).

The "crista medialis," a ridge of the humerus which, according to Ecker (**4**, p. 42), occurs among the males of three European species of *Rana* as a sexual difference, is not to be found in the males either of *R. hexadactyla* or of *C. systoma*. The wrist-bones of the latter show greater calcification than those of *Rana*; they also exhibit certain differences in their shape and in the details of their articulation with one another. In addition to the three bones of the proximal row mentioned by Ecker, one very often finds a fourth bone, which is exceedingly small, situated above and between the os pyramidale and the os lunatum. This may be a sesamoid bone, as it is placed in the course of a tendon (text-fig. 7 **B**).

Text-figure 7 (**A** and **B**).

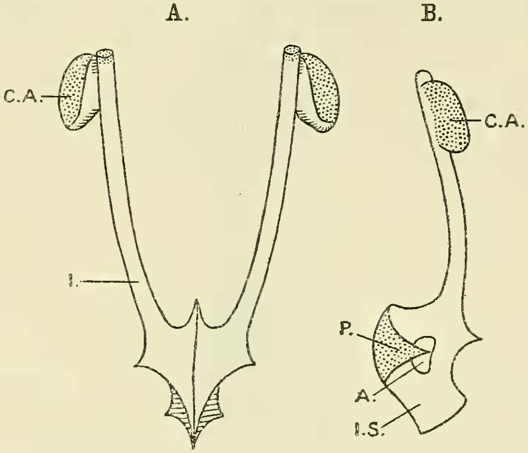


A. The pectoral girdle of *Cacopus systoma*. X., xiphisternum; C., coracoid; S., scapula; S.S., suprascapula; B., an apparently bony portion of the latter.

B. The bones of a manus of *Cacopus systoma*. S., a sesamoid bone situated in a tendon; H., vestigial first finger. For other letters consult the key-list of abbreviations.

In the pelvic girdle the absence of the iliac crest is remarkable when one finds that none of those muscles connected with the same crest in *Rana* is absent. Whether this crestless condition of the ilia as well as that of the urostyle denotes a primitive feature, or whether it is a sign of degeneration, cannot be easily settled for the reason indicated above. At the free anterior end of each ilium there is found, attached to its outer side, a peculiar cartilaginous appendage. This has the shape of a plate, which, by folding on itself, encloses a groove into which is received the cartilaginous free edge of a sacral diapophysis. Thus the sacrum movably articulates with the ilium (text-figs. 8 & 10). In other words, the pelvic girdle, by means of the ilia, forms a gliding joint with the backbone through the sacrum. On the contrary, the sacral transverse processes in *Rana* are immovably attached by tissue to the anterior ends of the ilia, and consequently no movement in the manner mentioned above could take place. I was able to observe in emaciated specimens the ilia moving obliquely backward and forward during the act of burrowing. I should therefore suppose that this gliding joint has something to do with the same habit of burrowing.

Text-figure 8 (**A** and **B**).



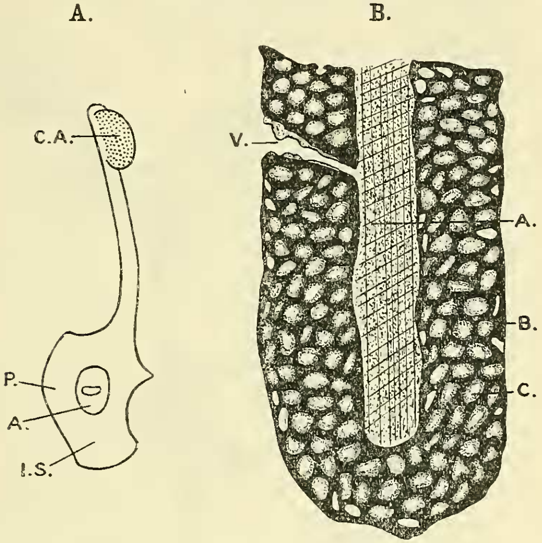
A. The pelvic girdle of *Cacopus systoma* viewed from above. I., ilium; C.A., cartilaginous appendage of the latter.

B. The same girdle seen sideways. P., pubis; I.S., ischium; A., acetabulum.

Beddard (**1**, p. 12), with reference to a cartilaginous plate unconnected with the ilium but covering the sacral diapophyses in *Breviceps verrucosus*, remarks as follows:—" I imagine that this cartilage belongs to the ilium, and that it is in consequence related to it as the suprascapula is to the scapula. We have, in fact, in this frog an exaggeration of the grooving which the anterior end of other forms shows at its line of articulation with the sacral vertebra. It is, moreover, interesting to observe that we find in this frog a kind of foreshadowing of the relations which the ilia bear to the sacrum in the higher Sauropsida, especially birds where the ilia are not merely attached to but cover the sacral vertebræ." In this Indian toad, however, the cartilaginous appendage in question not only covers the epiphysis of a sacral transverse process, but is also attached to an ilium. From the outer surface of the same appendage arises the *ilio-lumbaris*, a muscle which in *Rana* starts from the distal end of the ilium. These facts probably indicate that it really belongs to the latter, in which case the remarks quoted above may be, with less diffidence, applied also to the same ilio-sacral relation in *Cacopus*.

The pubis is interesting, as it exhibits signs of ossification which, if real, would be another anticipation of what occurs normally among the higher vertebrata. In older specimens the ilium and the ischium appear to gradually encroach upon it till, at last, in very old ones, it becomes indistinguishable from either of them, both in its area and in its appearance (text-fig. 9 **A** and **B**). This suggests that, while there may be an ossification of the same, it has no separate centre, and that the process of substitution progresses from the adjacent boundaries of the ilium and the ischium. Sections through such a pubis after decalcification with picric acid show a structure which may be interpreted as an

Text-figure 9 (**A** and **B**).



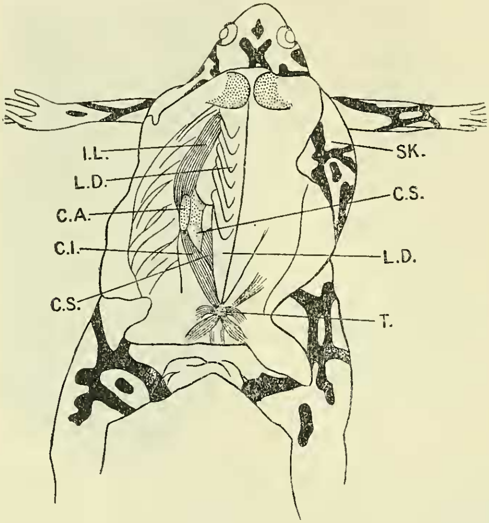
A. A side view of the three bones of the pelvic girdle of an old adult *Cacopus*. It will be seen that the boundary of the pubis is indistinguishable; letters as in text-fig. 8 (**A** and **B**).

B. A transverse section through the same pubis which suggested ossification. A., mass of degenerate cartilage at the symphysis: B., supposed network of bony tissue; C., degenerating cartilaginous matrix; V., probably a passage for a blood-vessel.

incipient stage in ossification by substitution (text-fig. 9 **B**). No cartilage cell could be seen. The Haversian system may not be expected, as the pubis, if at all ossified, is more likely to become a spongy or cancellated bone. A median translucent mass (A.) found at the symphysis, I presume is a residue of the decaying cartilage not yet replaced. In this connection, I may mention that a similar phenomenon has been noticed in another toad, namely *Pelobates* (Gadow, p. 27).

Among the bones of the hind-limb, the femur, the "os naviculare," and the prehallux deserve attention. There is, on the ventral side of the femur, a distinct crest stretching from the middle to the anterior end, stopping short of the head of the same. It is from this "femoral crest" that the vastus internus muscle arises. To this crest is also attached a considerable number of fibres of the *adductor longus*, *adductor brevis*, and the *pectineus* (text-fig. 19 **B** and **C**).

Text-figure 10.

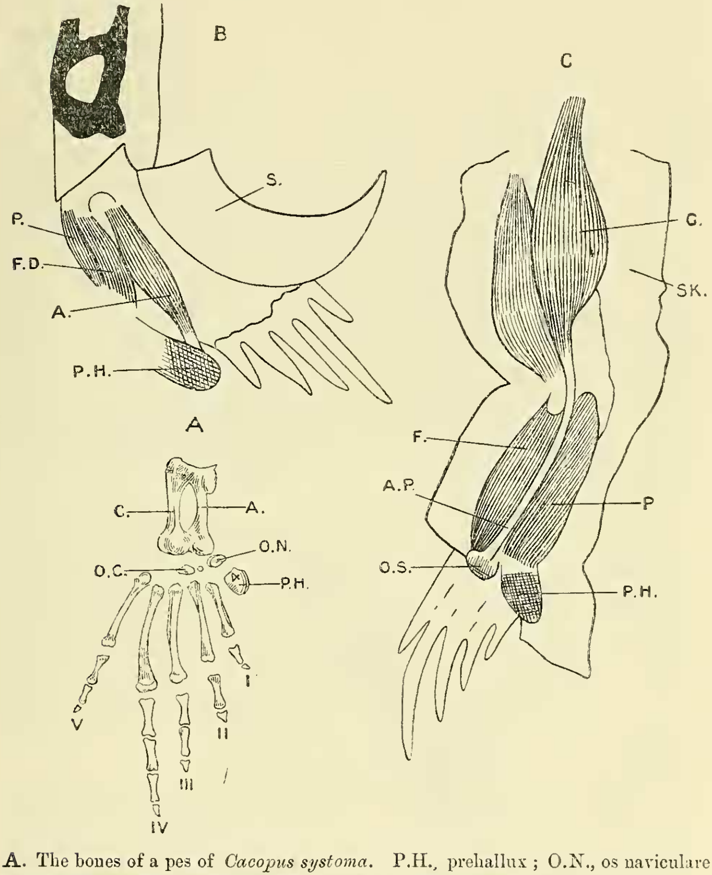


A dorsal view of the ilio-sacral joint and a few muscles connected with the same. For lettering consult the key-list of abbreviations.

The os naviculare in the tarsus of this toad is a circular disc, convex in front and concave behind, and articulating exclusively with the astragalus. In front it is bound by tissue, and articulates as well with a certain piece of highly calcified cartilage which, as will be seen presently, is homologous with the prehallux of *Rana*. Though the tarsal bone in question has become so closely associated with the prehallux as to look like one of the component pieces of the latter, yet its identity could be recognised with certainty by its connection with the muscle *adductor longus digiti* I (Ecker, p. 109; & text-fig. 11 A).

On the plantar surface of the foot in several forms of the Anura,

Text-figure 11 (A, B, and C).



A. The bones of a pes of *Cacopus systoma*. P.H., prehallux; O.N., os naviculare; A., astragalus; C., calcaneum; O.C., os cuboideum.

B. A side view of a pes of *Cacopus*, showing the relation of the muscle *abductor hallucis* A. to the prehallux P.H. P., *plantaris*; F.D., *flexor digitorum*; III, IV, and V, *longus*; S., skin cut and deflected upward.

C. The skin (Sk.) on the plantar surface of the same, cut and deflected sideways in order to expose the muscles connected with the tubercles in question. G. *gastrocnemius*, showing its relation to the "os sesamoide" (*o.s.*) or the outer metatarsal tubercle; P., plantaris inserted by means of a fascia on to the prehallux (P.H.) or the inner metatarsal tubercle.

particularly in those with a fossorial habit, has been observed a certain prominent tubercle of a horny consistency. It would appear that till now this has been generally regarded as a cutaneous structure, rendered hard and horny in consequence of the nature of its function which is the scooping-out of the soil in suitable localities. This Indian toad has two such conspicuous tubercles, called by Boulenger (2) the "inner metatarsal tubercle" and the "outer metatarsal tubercle." On maceration, it was found that not only these were not purely cutaneous developments, but also that they had their counterparts in *Rana*.

It is a well-known fact that the Anura possess, in addition to the five toes normally present, an extra vestigial digit—the prehallux. Among the Indian frogs I examined, this digit consisted of four cartilaginous pieces in *Rana hexadactyla*, of two pieces in *Rana tigrina*, and of a single piece in *Rana breviceps* and *Cacopus systoma*. The first-mentioned frog is entirely aquatic in habit, and its prehallux forms a slight projection covered with ordinary skin, while in the three last-mentioned ones, which are burrowing forms, the same prehallux is converted into a conspicuous shovel-shaped organ enclosed in a hard and horny dermal sheath (text-figs. 11 **A** & 12 **A**, **B**, and **C**). The so-called "inner metatarsal tubercle" of *C. systoma* is therefore none other than the distal piece of the vestigial toe of *Rana* which has acquired a large size and a shape suitable for its function in this toad. That this is so was confirmed by an examination of its connection with a muscle, viz. the *abductor hallucis*, which is inserted on to the prehallux—a muscular relation identical with what obtains in *Rana* (Ecker, p. 109).

In the two terrestrial species of *Rana* just mentioned, one finds a gradual reduction in the number of pieces constituting the prehallux, assuming the condition in *R. hexadactyla* to be the normal one. Simultaneously with this reduction, it would appear that in these forms there has been an increase in the size and a change in the shape of the distal piece of the prehallux. This reduction, however, may be regarded as advantageous, for the fewer the number of joints in an organ employed for digging, the greater will be its efficiency. Thus we find in *C. systoma* a single large piece constituting the prehallux*.

It may be required why I homologise the single element of the prehallux of *Cacopus* with the distal piece and not with the proximal one in that of *Rana*. As the latter piece is in contact with the os naviculare, just as that of the prehallux of *Cacopus* is, one may be inclined to the alternative opinion mentioned. But a careful reference to the text-fig. 12 **A**, **B**, and **C** will show that my view is the more probable one; for it will be seen that while in *Rana tigrina* the distal piece numbered 4 undoubtedly corresponds to the same piece 4 either in *Rana breviceps* or in *Cacopus systoma*, in the latter two species the proximal piece 1 of the former has disappeared. According to the alternative view, one will have to say that the distal piece 4 of *Rana tigrina* has disappeared in *Rana breviceps* and *Cacopus*, and the proximal piece 1 has acquired a shape similar to piece 4; this explanation appears more ingenious than natural. Further, in accordance with the function of the prehallux in these frogs, it will be a distal piece which will come into direct play, and it will consequently lend itself to an adaptation in shape and size.

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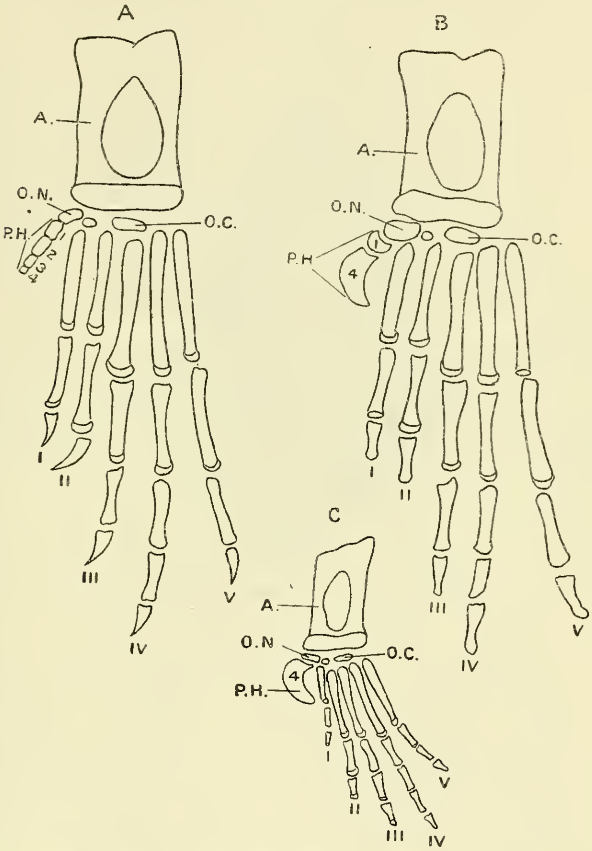
* I venture to suggest that the so-called spade of the "Spade-footed Toad" or *Pelobates* of Europe is also the prehallux modified.

Text-figure 12 (**A**, **B**, and **C**).



A. The bones of a pes of *Rana hexadactyla*. Lettering same as in **A** of text-fig. 11. It will be noticed that the prehallux consists of four pieces.

B. The same of *Rana tigrina*. The prehallux is made up of only two pieces, viz. 4 and 1; 2 and 3 have probably disappeared. One may alternatively assume that 3 and 4 of *R. hexadactyla* have been omitted, and that 4 in *R. tigrina* corresponds to 2 in the latter. Lettering same as in text-fig. 11 **A**.

C. The same of *Rana breviceps*. The prehallux is composed of but a single piece, like that of *Cacopus*. Lettering same as in text-fig. 11 **A**.

In this toad a further specialisation of the digit in question seems to have been brought about in its relation to the tarsus. It is firmly attached to the os naviculare, as has been already described in connection with the latter, and through the intervention of the same it articulates exclusively with the astragalus. This articulation, I should think, in combination with the action of the muscles attached to it and to the tarsal bone mentioned, bestows a considerable advantage in the act of burrowing (text-fig. 11 **B** and **C**). In *R. tigrina* and *R. breviceps* the specialisation has not been carried to that extent; the same indirect articulation of the prehallux with the astragalus is only partial, as the first digit still continues to articulate with the latter indirectly through the os naviculare; further, the prehallux and the tarsal bone connected with it are, in these frogs, much less calcified, and consequently they are less rigid and hard. Again, the *plantaris* muscle, which has no relation with the prehallux in *Rana*, has a connection with the same in this toad, in that it is indirectly inserted on to the latter by means of a fascia (text-fig. 11 **C**).

It is exceedingly interesting to find the digit, which is generally believed to be a vanishing structure in the Anura, re-asserting itself under suitable conditions and becoming an organ of no mean importance to its possessor. This specialisation of the prehallux among the species of two different families, viz. the Engystomatidæ and the Ranidæ, may be regarded as a case of convergence.

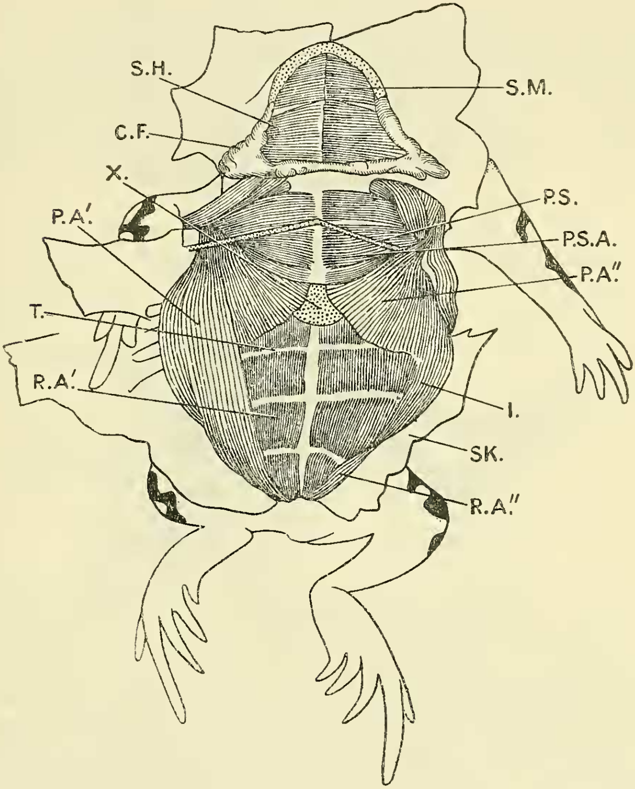
The "outer metatarsal tubercle" of this toad, though smaller than the inner one, consists likewise of a single cartilaginous piece covered with a horny dermal layer. I identify this as the "os sesamoide" (Ecker, p. 106) of *Rana*, which is a cartilaginous element situated on the plantar side of the joint between the calcaneum and the fourth metatarsal bone. In this latter position exactly I found the cartilage of the "outer metatarsal tubercle" situated in *C. systoma*, so that this also is no new structure developed by this toad, but is only a specialised and an exaggerated one of what is normally present in *Rana*. Nevertheless, it would seem that a remarkable specialisation had been brought about in its alliance with no less an important muscle than the *gastrocnemius*. To this "os sesamoide" is exclusively inserted the narrow, attenuated yet strong band of the *aponeurosis plantaris*. This implies that an important calf muscle is concerned in the working of the "outer metatarsal tubercle" (text-fig. 11 **C**).

7. *The Musculature.*

The muscles of the hyoid apparatus and of the floor of the mouth are characterised by a great specialisation in this toad, a remarkable fact observed also by Beddard (**1**) in three other members of the same family. However, in the details of the specialisation, excepting perhaps in the *sternohyoideus*, one does not find any features which could be distinguished as common to *Cacopus* and to those described by the authority mentioned.

We will follow Beddard in calling the posterior portion of the *sub-maxillaris* the *sub-hyoideus*, and in restricting the original name to the anterior portion of the same muscle. Now this "*sub-hyoideus*" is much larger than the *sub-maxillaris*—the reverse of what obtains in *Rana* (text fig. 13). The proportion which the former muscle assumes in the male is in conformity with the differentiation of a median vocal sac. It is a posterior portion of this muscle which, along with the skin in this region, becomes enormously expanded to form a large spherical resonator

Text-figure 13.

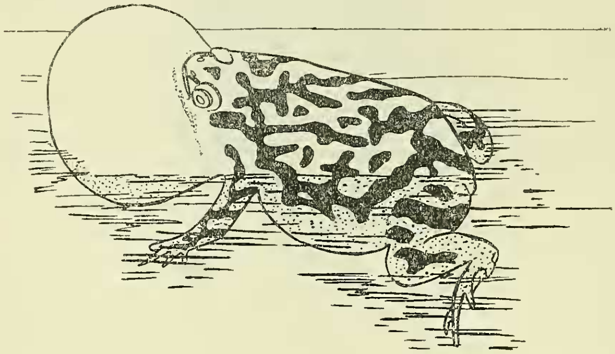


Certain muscles on the ventral surface of the trunk and head of *Cacopus systoma* have been exposed. T., an *inscriptio-tendina* of the inner division of the *rectus-abdominis*; C.F., ventral extension of the "cervical fat-body"; I., the spot where the outer division of the *rectus-abdominis* and that of the *portio-abdominis* are attached to the skin; P.S., pectoral septum; S.M., *sub-maxillaris*; S.H., *sub-hyoideus*. For other letters see key-list of abbreviations.

during the time of croaking (text-fig. 14). When at rest, this part of the muscle is withdrawn and stowed away in a conspicuous double fold above the anterior portion of the same muscle.

On removing the *sub-maxillaris* and the *sub-hyoideus* several inner muscles of the floor of the mouth come into view (text-fig. 15). It is seen that the transverse fibres of the *sub-mentalis* (S.M.) pass from the inner border of one mentomeckelian to that of the other, thus having apparently * no connection with the dentary. It is also seen that a greater part of the same muscle is connected with the cartilaginous piece borne by each mentomeckelian, which has been already described in the section on the axial skeleton. Of greater interest is the *genio-hyoideus* muscle, whose origin and insertion are very different from what obtains in *Rana*. The outer portion of this muscle arises from the angulosplenial and passes on the outer side of the mentomeckelian cartilaginous piece and that of the *sterno-hyoideus* muscles to be inserted on to the posterior cornu (text-figs. 15 & 16 A). Though it is widely separated from the inner division, it is connected with the latter by some of its fibres, which diverge from its body at about the place of origin and become confluent with the same inner portion, so that on the right side of the toad this outer portion and that part of the corresponding inner division lying in the pre-hyoid part of the floor of the mouth have together the shape of the letter N. It will be noticed that a few of the connecting fibres are intercepted

Text-figure 14.



A male *Cacopus* with the vocal sac in action; drawn from life; half natural size. The enormous distension of the vocal sac is remarkable; under natural surroundings it looked more like a float than a resonator.

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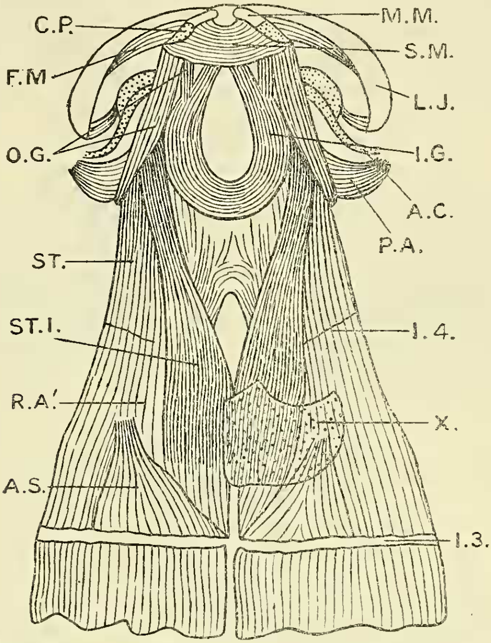
* It looks as though the cartilaginous part of the mentomeckelian has insinuated itself across the fibres of this muscle; for one finds between the outer side of this same part of the lower jaw several muscular fibres which I presume belong to the *sub-mentalis* (text-fig. 15, F.M.).

by the cartilaginous portion of the mentomeckelian (text-fig. 16 A). The inner divisions of the two *geniohyoideus* muscles are still further remarkable, for, in the region of the basi-hyal, they fuse * to form an extensive median sheet of muscle with two posterior offshoots, each of which, spreading on a posterior cornu, entirely conceals the *hyoglossus* muscle in the usual position of the toad during dissection. The insertion of the former, in consequence of its extensiveness, is extraordinary; for it consists of a perimeter of the inner lateral edges of the two posterior cornua and the hind border of the basi-hyal enclosed between these two cornua, thus forming a parabolic curve (text-fig. 16 B, G.″).

Text-figure 15.



A view of certain superficial muscles of the hyoid and deep-lying ones of the floor of the mouth. The lower jaw (L.J.) has been divaricated; the *sub-maxillaris* and the "*sub-hyoideus*" have been removed; a right half of the xiphisternum has been cut away in order to expose at their origins the inner portion of the *sternohyoideus* (ST. I.) and the "*abdominis-sternalis*" (A.S.). R.A., continuation of the "inner division of the *rectus-abdominis*" as the "outer portion of the sternohyoideus" ST.; I.3 and 1.4, third and fourth *inscriptio-tendina* of R.A.′ respectively; F.M., certain muscle-fibres between the lower jaw and the cartilaginous part of a mentomeckelian. For other letters consult the key-list of abbreviations.

The single "outer portion of the *sternohyoideus*" (or the sternohyoideus proper) has differentiated into two separate muscles in this toad, one lying above the other. This differentiation starts at the fourth and the last *inscriptio-tendina* of the *rectus-abdominis*. A similar division of this muscle has been observed in *Breviceps* and *Hemisus* by Beddard (1). What corresponds to the "inner (median?) portion of the same muscle" is a strip which arises entirely from the xiphisternal plate (text-figs. 15, ST. I., & 16). Now, these three divisions of the *sterno-hyoideus* are separately inserted on to the body of the hyoid, one behind the other and in close succession; none of the fibres, however, is attached either to the posterior cartilaginous process of the same hyoid plate or to the posterior cornu.

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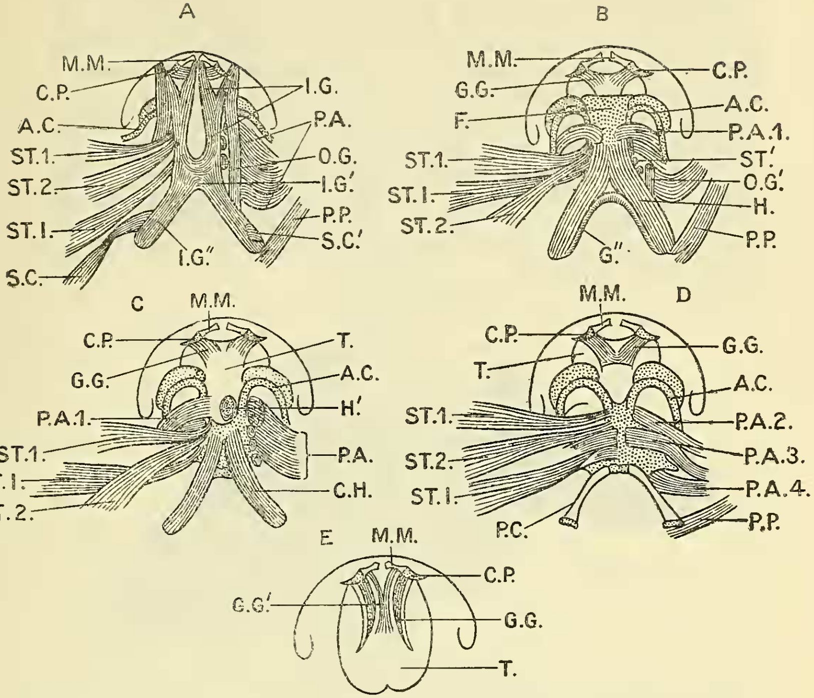
* A condition similar to this has been observed by Beddard (1) in *Breviceps*.

On removing the hyoid portion of the inner *genioglossus* muscles, the *hyoglossus* pair comes into view which, in turn, conceals another muscle in the ordinary position of dissection. The thick, coarse fibres in the interior of the azygous portion of the *hyoglossus* are either sinuous or twisted like a corkscrew. As this muscle is the retractor of the tongue, this condition, at rest, of the fibres mentioned suggests that they are capable of being stretched to a greater extent than usual so as to permit the tongue to reach a comparatively longer distance. In *Rana* the paired portion of the same *hyoglossus* is the innermost muscle in contact with the lower surface of the posterior cornua; but, in this toad, there intervenes a new pair of muscles between the two, which arises from the distal quarter of the latter, and is inserted to a strong fascia spreading in the space enclosed by the proximal parts of the anterior cornua and the anterior margin of the basi-hyal (text-fig. 16 **C**, C.H.). Among the muscles connected with the hyoid skeleton, there are several which are solely attached to the posterior cornua on the one side and to the bones of the skull and of the pectoral girdle on the other. Now, it is likely that this new muscle, which we may term the *cornuoideus-posterior*, counteracts a probably too powerful pull of these muscles in question on the same cornua by binding the latter with the basi-hyal plate. One finds another new pair of muscles, not recorded in *Rana*, arising from the xiphisternum and running forward beneath the auricle to be attached to the posterior cornu (text-fig. 16 **A**, S.C.); this may be called the *sterno-cornuoideus* in accordance with its origin and insertion. The petrohyoideus muscles are distinguished by their robust development and by their numerous insertions. The *petro-hyoideus-anterior* arises from the pro-otic by means of a single tendon, and spreads over the outer surface of the pharynx, to whose wall all its fibres are more or less adherent (text-fig. 16 **A**, **B**, **C**, and **D**). According to the several insertions of this muscle, one may recognise the following divisions: (1) a band, P.A. 1, inserted on to the fascia in relation with the proximal parts of the anterior cornua; (2) another anterior portion, P.A. 2, attached to the root of the same cornua; (3) a small narrow division, P.A. 3, attached to the lower surface of the basi-hyal; and (4) a

Text-figure 16 (A, B, C, D, and E).



A. The deep muscles of the hyoid and of the floor of the mouth. The *submentalis* has been taken away. The *sterno-hyoideus* muscles on the right side have been severed at their origins and deflected while those on the left have been removed. O.G., an outer division of the geniohyoideus; I.G., an inner one of the same; I.G'., a fused median portion of I.G.; I.G.'', a posterior offshoot of I.G.' concealing a hyoglossus below; S.C., *sterno-cornuoideus*; S.C.', cut end of the same. For other letters consult the key-list of abbreviations.

B. The deep muscles of the hyoid continued; the *geniohyoideus* muscles have been removed excepting those fibres of I.G.' and I.G.'' at their insertion (G.'') which, as will be seen, is a parabolic curve. ST.1 and ST.2, the two divisions of the "outer portion of the *sternohyoideus*" or the "*sternohyoideus* proper." P.A.1, an anterior division of the *petrohyoideus*; O.G.', cut end of the outer *geniohyoideus*; ST.', cut ends of the *sternohyoideus* muscles; F., fascia; H., *hyoglossus*. Other letters as in **A**.

C. The same muscles continued. The *hyoglossus* in the region of the basihyal has been cut away. C.H., "*cornuoideus-posterior*"; H'., cut end of the azygous *hyoglossus*; P.A., *petrohyoideus-anterior*; P.A.1, an anterior division of the latter. The remaining letters as in the other figures of this text-figure.

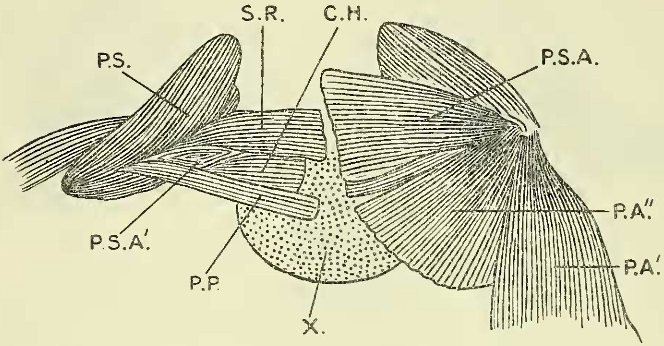
D. The same muscles continued. The "*cornuoideus-posterior*" has been removed. P.A.2, P.A.3, and P.A.4, the several bundles into which the *petrohyoideus-anterior* separates itself before its insertion; P.P., *petrohyoideus-posterior*. For other letters consult the key-list of abbreviations.

E. Certain muscles of the tongue viewed from below. The median and azygous part of the *genioglossus* (G.G.) has been cut in the middle in order to expose the muscle G.G.', which corresponds to the outer portion of the *genioglossus*.

posterior thick division, P.A. 4, inserted on to the upper surface of the same plate. As regards the *petrohyoideus-posterior* (P.P.), while a small part of it clings to the cartilaginous free end of a posterior cornu, the bulk of the fibres pass above the latter and are inserted to the pharynx, a few fibres reaching also to the larynx. I could not find any trace of the *omo-hyoid* muscle, a negative feature observed also in *Breviceps* and *Hemisus*.

Of the muscles of the tongue, it may be noted that the relative position of the two divisions of the *genioglossus* has undergone an alteration. The one corresponding to the outer part in *Rana* lies above the other corresponding to the median part of this muscle. Further, the former has shifted its insertion from the mucous membrane of the floor of the mouth to the body of the tongue (text-fig. 16 E).

Text-figure 17.



View of certain muscles of the chest. On the right side the *portio-sternalis-anterior* and the *portio-abdominis* have been removed. S.R., *sterno-radialis*; P.S., *portio-scapularis* or the vestigial *deltoideus*; P.S.A., *portio-sternalis-anterior*; P.S.A′., cut end of the same on the right; C.H., *coraco-humeralis*; P.A′., outer division of the *portio-abdominis*; P.A.″, an inner division of the same muscle; X., xiphisternum.

It seems to me that the specialisation described above of the muscles of the hyoid and of the floor of the mouth is in some way connected with a more efficient method of obtaining food.

The muscles of the chest as a whole, with the exception of the *portio-sternalis-anterior* and the *portio-abdominis*, exhibit a feeble development (text-figs. 13 & 17). This, in my opinion, is mainly due to the disappearance of the pre-coracoid, the omosternum, and the episternum. For instance, the *sterno-radialis*, which arises in *Rana* from the three elements of the pectoral girdle mentioned, has its origin shifted to the inner ventral border of the coracoid, which is less extensive; consequently this muscle is vestigial*. Again, the *deltoideus* exhibits a degeneration in the absence of one of its two divisions, viz. the *pars-clavicularis*. It would also appear that as the functions of these two muscles of the chest have become reduced to a minimum in this toad, a large size and an extensive origin for the same have been rendered unnecessary. According to Ecker (4), in *Rana* the *sterno-radialis* is a powerful flexor of the fore-arm, and the *deltoideus* draws the same limb forwards. These movements, though essential to a good swimmer, are in all probability of only a limited use to a terrestrial frog. Thus it becomes difficult to say whether the vestigial condition of the chest-muscles led to the disappearance of certain of the elements of the pectoral girdle, or the latter condition necessitated the former. It is more probable that the two degenerative processes might have proceeded concomitantly.

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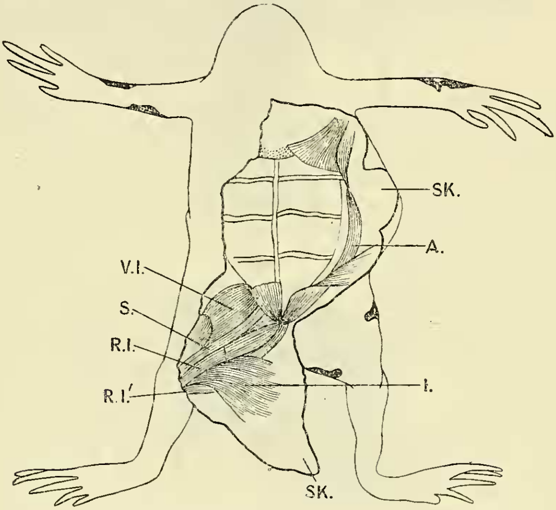
* In this connection it may be mentioned that this muscle is absent in *Breviceps* (1).

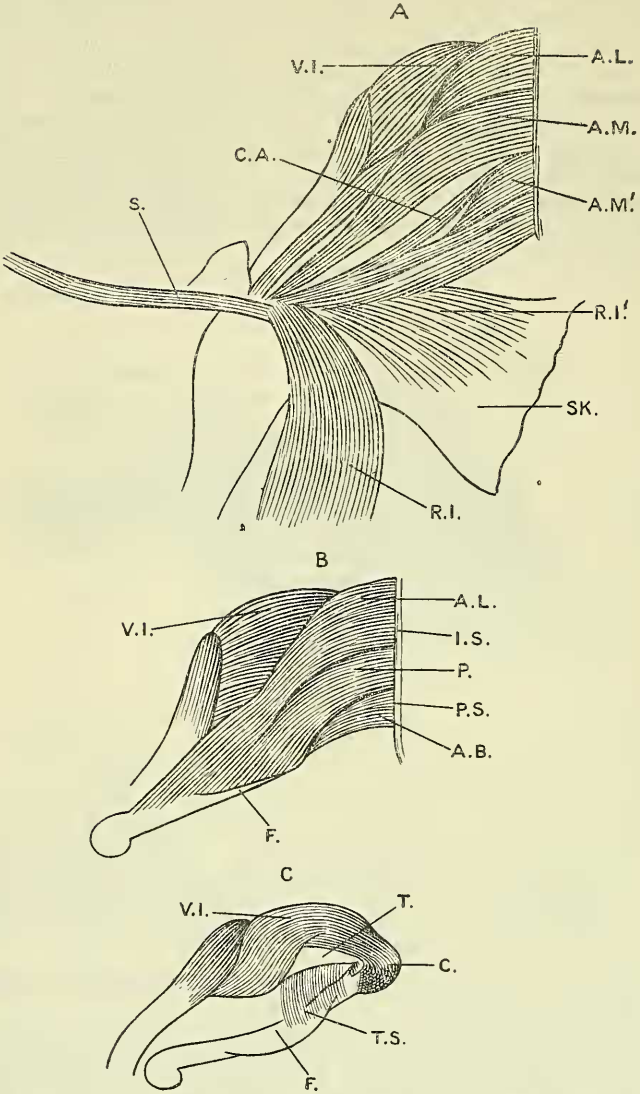
Text-figure 18.



A ventral view of the trunk and a thigh with the skin cut open in order to show the relation of certain muscles with the skin. I., several fibres of the *rectus-internus-minor* (R.I′.) arising from the skin (SK.) on the lower surface of a thigh; A., the region of the skin from which the outer division of the *portio-abdominis* starts and to which that of the *rectus-abdominis* is inserted; S., sartorius; R.I., *rectus-internus-major*; V.I., *vastus-internus.*

On the contrary, one finds that the *portio-sternalis-anterior* and the *portio-abdominis* muscles have attained a great development, and the outer division of the latter has become partially converted into a cutaneous muscle (text-fig. 18). The attachment to the skin has, I should think, given additional purchase to this muscle in pulling the front limb backwards and towards the body, as happens while burrowing. These two chest-muscles are probably put to a greater use in this toad at the expense of the *sterno-radialis* and the *deltoideus.*

Text-figure 19 (A, B, and C).



A. Certain muscles on the lower surface of a thigh. C.A., *caput-anticum* of the *semi-tendinosus*; A.L., *adductor-longus*; A.M., *adductor-magnus*; A.M'., a hind portion of the same. Other letters as in text-fig. 18.

B. Most of the muscles on the lower part of the thigh have been removed in order to show a few deep ones. A.L., *adductor-longus*; P., *pectineus*; A.B., *adductor-brevis*; F., a crest of the femur; I.S., iliac symphysis; P.S., pubic symphysis.

C. A view of the *vastus-internus* (V.I.) showing the details of its origin. C., capsule of the hip joint; F., a crest of the femur; T.S., a band of tendinous strips starting from a strong tendon (T.).

The *rectus-abdominis* muscle of the trunk is remarkable for having shifted its origin backward from the pubes to the ischia; its outer portion is, along the greater part of its length, adherent to the skin below. This is significant when viewed along with the absence of the *cutaneus-pectoris* in this toad. At the third inscriptio-tendina of each *rectus-abdominis* one finds a small triangular portion, separated off from its main body, passing forward and attached to the upper side of the xiphisternal plate (text-fig. 15, A.S.). This muscle, which we may call "the *abdominis sternalis*," should be regarded as a differentiated part of the inner portion of the *rectus-abdominis*, for in *Rana* some of the fibres of the latter in the same situation are attached to the xiphisternum. While the *rectus-abdominis* muscles are generally thin and attenuated, the *obliquus* muscles are better developed and are thrown into transverse puckers, and bulge out prominently on the sides on account of the pressure of the enormously developed viscera.

Among the muscles of the thigh, the *rectus-femoris-anticus* is absent, the *triceps-femoris*, composed of three divisions in *Rana*, is made up of only two, and the origin of the *vastus-internus* is somewhat different. Though most of the anterior fibres of the last arise from the capsule of the hip-joint, the rest of them arise from a long tendon given off by the same capsule (text-fig. 19 **C**, T.). Further, this tendon is adpressed to the shaft of the femur by tendinous slips which spring from it laterally. On one side of the tendon, namely the inner lower side, these slips are so closely set as to form a band (T.S.). As regards the *rectus-internus-minor*, one finds that, on its lower side, a considerable number of fibres take origin on the skin of the thigh (text-figs. 18 & 19 **A**). This partially cutaneous origin of the muscle recalls a similar condition in the frogs described by Beddard (**1**). The *semi-tendinosus* is inserted by a narrow tendon which spreads in a triangular form over the anterior head of the tibio-fibula, in this respect differing from that of *Rana*, where the tendon in question unites with that of the *sartorius* to form an aponeurotic arch. The *adductor-longus*, the *pectineus*, and the *adductor-brevis* may be considered as forming a single muscle, for they are not distinctly delimited from one another. The greater portion of this huge muscle is hidden from view by the *sartorius* and the *adductor-magnus*, and where it is inserted on to the shaft of the femur its fibres along the middle are firmly attached to a crest of the femur already mentioned (text-fig. 19 **B**).

8. *Summary.*

(1) In the pharynx a new structure is situated to which the status of an organ may be given, and it has been accordingly named "the pharyngeal organ of *Cacopus systoma*."

(2) Sub-cutaneous as well as sub-peritoneal fat-bodies are normally present in this toad; while the former are developed

in relation to the lymphatic septa, the latter are probably deposited in connection with the peritoneal membrane. Their function, as has been ascertained, is to assist in the general metabolism of the body during æstivation.

(3) The stoutness of this toad is, in the first instance, due to the enormously developed viscera. This condition is improved upon by the inclusion of a part of the thigh into the contour of the trunk and by the enlarged sub-cutaneous lymph-sinuses.

(4) In the skeleton the vestigial state of several of the bones of the head is remarkable. This and the consequent engystomatous mouth are, in my opinion, related in some unknown manner to the nature of the diet, which consists almost entirely of termites*, winged or wingless according to the season. Witness, in this connection, the similar effect produced by a similar diet on the Myrmecophagidæ among Mammals.

(5) It is noteworthy that the pre-hallux of *Rana*, usually regarded as a degenerate digit, has in this toad become an organ with a definite function, viz. the so-called "inner metatarsal tubercle."

(6) While certain muscles, for example the *sterno-radialis* and the *deltoideus*, show a remarkable degeneration, other muscles, for instance the muscles of the hyoid and of the floor of the mouth, exhibit an equally remarkable specialisation. The muscles examined also show important differences in their relative dimensions, origins, and insertions. Certain new muscles are present which have been already described, while three muscles are absent, viz. the *cutaneus-pectoris*, *omo-hyoid*, and the *rectus-femoris-anticus*. Again, certain non-cutaneous muscles of *Rana* have acquired a partial connection with the skin, for example, the *rectus-internus* and the *portio-abdominis*. Assuming the muscular anatomy of *Rana* to be typical of the Anura, one may trace the differences in the musculature of this toad to two factors, viz. the fossorial habit and the nature of its food. This creature passes the greater part of its life underground, seeking water only for breeding purposes. This implies that, while the same muscles called into frequent activity in an aquatic frog may suffer by the want of regular use, other muscles of a direct utility in burrowing are likely to be improved and exaggerated. At the same time, the curiously specialised muscles of the hyoid and of the floor of the mouth probably indicate a more efficient method of capturing insects.

(7) Beddard (1) mentions three characters which may be common to the Engystomatidæ: these are (1) the partially cutaneous origin of the *rectus-internus-minor*, the specialisation of the muscles of the floor of the mouth, and the division of the "outer portion of the *sternohyoideus*." One may say that in

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* Although it is true that insects form the chief food of frogs in general, yet a liberal diet of termites alone appears to produce the peculiar effect on the constitution which we have indicated.

these respects *Cacopus systoma* also agrees with the three genera described by him. Nevertheless, in the details of the second feature mentioned there is hardly any striking resemblance. I should add that the *omo-hyoid* muscle is generally absent among the same family, as it has not been found either in this toad or in *Breviceps* and *Hemisus*.

9. *Key-list of certain of the Abbreviations mostly unexplained in the explanations to Text-Figures.*

A.C.—Anterior cornu.
A.H.—Articular head for the lower jaw.
C.P.—A cartilaginous part of the mentomeckelian.
C.S.—Cartilaginous epiphysis of the sacrum.
C.S.'—*Coccygeo-sacralis.*
C.I.—*Coccygeo-iliacus.*
Ex.O.—Ex-occipital.
Fr.P.—Fronto-parietal.
I.G.—Inner division of a *genio-hyoideus.*
I.L.—*Ilio-lumbaris.*
L.D.—*Longissimus-dorsi.*
M.—Maxilla.
M.M.—Mentomeckelian.
Na.—Nasal.
O.C.—Occipital condyle.
O.C.H.—"Os-capitato-hamatum."
O.E.—*Obliquus-externus.*
O.G.—Outer division of a *genio-hyoideus.*
O.I.—*Obliquus-internus.*
O.L.—"Os lunatum."
O.N.—"Os naviculare" of a manus.
O.P.—"Os pyramidale."
O.T.—"Os trapezium."
O.Ts.—"Os trapezoides."
Pr.—Pterygoid.
P.A.—*Petrohyoideus-anterior.*
P.A.'—Inner division of a *portio-abdominis.*
P.A."—Outer division of the same.
P.M.—Premaxilla.
P.P.—*Petrohyoideus-posterior.*
Pro.O.—Pro-otic.
P.S.—Parasphenoid.
Q.—Quadrato-jugal.
R.A.'—Inner division of a *rectus-abdominis.*
R.A."—Outer division of the same.
SQ.—Squamosal.
ST.—"Outer portion of the *sterno-hyoideus*" or the *sterno-hyoideus* proper.
ST. 1 and ST. 2.—Two divisions of the same.
ST. I.—An inner portion of the *sterno-hyoideus.*
S.H.—"Sub-hyoideus."
S.M.—Sub-maxillaris.
S.M.'—Sub-mentalis.
T.—Tongue.
T.'—Terminal epiphysis of the urostyle.
V.—Vomer.
X.—Xiphisternal plate.

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